REMARKS

The Examiner is thanked for withdrawing the rejection over Komei and issuing a second non-final Action. The Applicant respectfully traverses the new anticipation rejection over Ryan '435. Claim 1, with notations to the exemplary embodiment of the disclosure, reads

> *A method of manufacturing a semiconductor device, comprising:*
> *embedding a copper wiring layer* [4] *in an insulation layer* [1];
> *forming a compound of copper* [5] *into the copper wiring layer from thereabove;*
> *forming a reactive layer* [6] *on the compound of copper from thereabove;*
> *forming a barrier metal layer* [7] *on the reactive layer from thereabove; and*
> *interdiffusing the copper compound and the reactive layer by heat treatment to thereby form an alloy layer of copper* [8] *between the copper wiring layer and the barrier metal layer* [7].

An advantage of the claimed subject matter is that the compound of copper which is formed between the copper wiring layer and the barrier metal layer prevents an overreaction between the copper wiring layer and the reaction layer.

The Examiner is invited to note that the reactive layer is formed between the compound of copper and the barrier metal layer, and the alloy layer of copper is formed between the copper wiring layer and the barrier metal layer. With respect, these features are not disclosed by Ryan.

Diffusion. The Examiner applies text at col. 2, lines 32-38, where Ryan states that a "major problem with copper is its fast diffusion in Si and drift in SiO_2-based dielectrics." Prior to this, Ryan notes that copper is typically deposited in trenches in contact with SiO_2 (col. 2, lines 7-14), and further along Ryan states, "it is necessary to prevent ... interdiffusion between Cu and Si" (col. 2, line 47).

Although Ryan does disclose diffusion, this is seen to be a statement of physics rather than a disclosure of specific prior art. That is, Ryan discloses diffusion as something to be avoided, not as something that the person skilled in the art will do.[1] With respect, there is no diffusion in Ryan's disclosed embodiments:

Diffusion From Below. The SiO_2 of the cited text, which is in the Background section, is not what Ryan's copper is embedded in as described in the Detailed Description.[2] Ryan's Fig. 2, which is reproduced and applied in the rejection, does *not* illustrate the interdiffusion of copper and silicon because it shows a barrier layer 22 between the copper 23 and the dielectric 21 (col. 5, lines 45-51), which may be SiO_2 (col. 4, lines 10-29). This barrier layer will prevent interdiffusion, and there is no disclosure of copper diffusing into SiO_2 from below or from the sides.

Diffusion From Above. Furthermore, there is no diffusion from above (which is what the Applicant claims). In the embodiment of applied Fig. 2, Ryan "completely covers" the copper with a CrO layer 24 (col. 5, line 51) and this is a major feature of Ryan's invention (it is recited in claim 1 at col. 6, line 50). Ryan states that the CrO stops diffusion from above, saying that it "prevent[s] electrotransport of copper at the top surface" (col. 4, lines 49-55).

Oxidation Is Not a Prior-Art Step. Ryan discloses that "In this invention, oxidation of the copper surface is *prevented* up to about 400 °C" (col. 4, lines 56-57; emphasis added).[3] The reference does not disclose any step of forming an oxide of copper, it merely notes that copper oxide can form at high temperatures. As argued above, this is not a prior- art step.

---

[1] An analogy would be a reference describing an anti-seize compound for bolts; the disclosure is the compound, not the rust it prevents.

[2] The interdiffusion is discussed in col. 2, while Fig. 2 is discussed in col. 5.

[3] This is noted by the Examiner at page 4, line 2, as evidence that oxidation of copper is disclosed. With respect, however, any barrier will break down at *some* temperature and the teaching of Ryan is that the CrO *prevents* oxidation. Immediately after mentioning 400°C, Ryan states "Copper oxide is detrimental." That is, Ryan does not teach oxidation of copper as a method step, but as something to avoid. The step which Ryan teaches is covering the copper with CrO to *prevent* oxidation.

No Compound of Copper Is Disclosed. The CrO layer, which is in direct contact with the copper of Ryan, cannot anticipate the claimed compound of copper because it is a compound of chromium, not of copper.

Furthermore, since the Applicant recites forming the compound "into the copper" there can be nothing else in Ryan that anticipates this feature; the CrO is the only thing in contact on the side "thereabove."

There Is No Reactive Layer. The Examiner asserts that the silicon disclosed in the reference is the reactive layer disclosed in the instant claims (page 4 of the Office Action). However, Ryan's silicon is not formed between the copper layer and a barrier metal layer. Therefore, the reference does not disclose the reactive layer of the instant claims.

Furthermore, the disclosed silicon or SiO_2 is not above, but on the sides and below (as is discussed above).

Likewise, as Ryan states that the CrO layer is intended to prevent diffusion, this also is not a reactive layer thereabove.

There Is No Barrier Metal Layer. Ryan discloses no layer at all above the CrO layer (col. 5, lines 51-62), much less a barrier metal layer.

Claim 5. Claim 5 is similar to claim 1 but recites *forming a barrier metal layer containing a substance interdiffused with the copper wiring layer on the compound of copper.* The Examiner applies Fig. 1 of Ryan against claim 5. This figure shows stacked layers of dielectric with embedded metallization; the topmost 13 is copper, and it is covered with a layer 14 of CrO (col. 5, line 2). Thus, the structure is the same as in Fig. 2 and the arguments above apply to the rejection of claim 5 also.

Claims 17-18. Even if Ryan did disclose the step of oxidizing (not admitted), it still would not disclose the claimed steps in the order recited.

Withdrawal of the rejection and allowance of the claims is requested.

Respectfully submitted,

May 30, 2006
Date

Nick Bromer (Reg. No. 33,478)
(717) 426-1664
RABIN & BERDO, P.C.
CUSTOMER NO. 23995
Telephone: (202) 371-8976
Telefax : (202) 408-0924